**NASA DEVELOP National Program**



NASA Ames Research Center

*Summer 2017*

**Short Title: US Virgin Islands Ecological Forecasting**

**Subtitle:** Using NASA Earth Observations to Monitor Land-use Change and Map At-risk Coastal Habitats in the U.S. Virgin Islands

**VPS Title:** From Turf to Surf

**Project Team**

**Project Team:**

Rebecca Lehman (Project Lead), [rebecca.d.lehman@nasa.gov](mailto:rebecca.d.lehman@nasa.gov)

Bretton Alwood

Carrie Boyle

Erica Ta

**Advisors & Mentors:**

Dr. Juan Luis Torres-Pérez (Bay Area Environmental Research Institute)

Dr. Liane S. Guild (NASA Ames Research Center)

**Project Overview**

**Objectives Overview:**

In the past fifty years, the total population of the U.S. Virgin Islands has more than tripled to approximately 105,000 people. This population increase has intensified coastal development. Rapid land-use change and its associated impacts are placing pressure on the islands’ coastal environments, including mangroves, seagrasses, and coral reefs. We aim to define and predict future land-use trends, as well as identify highly impacted sub-watershed areas. The results of our work will be used by the U.S. Virgin Islands Department of Planning and Natural Resources to help inform future management and planning decisions.

**Abstract**

The United States Virgin Islands (USVI) are home to an array of diverse and stunning habitats. The beauty of the islands has continued to attract visitors and residents, which overtime has increased human development and impact. The resulting land-use change increases sediment loads and the flow of pollutants into surrounding nearshore environments such as coral reefs, mangroves, and seagrass beds. Coral reefs, the most diverse marine habitats on Earth, are particularly susceptible to these inputs. Compounded with regional climate-related processes such as rising ocean temperatures and acidification, future land-use change poses a formidable threat to the marine environment. Without a healthy environment, the USVI economy also becomes endangered because it is mainly supported by tourism and recreation. In order to assess land-use change in the USVI, we utilized Landsat 5 TM, Landsat 8 OLI and TIRS, and Sentinel-2 MSI data to map land-use and analyze land cover change dating back to 1985. We then extrapolated the models to the year 2025. Our work will provide the USVI Department of Planning and Natural Resources, Division of Coastal Zone Management (CZM) with a tool to better understand land-use trends, identify at-risk coastal habitats, and strengthen existing knowledge of the link between land-use and coastal ecosystem health.

**Keywords:**

Land use, Landsat, sedimentation, LU/LC, watersheds, United States Virgin Islands, nearshore ecosystems

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| US Virgin Islands Department of Planning and National Resources, Coastal Zone Management | Jean-Pierre Oriol, Director;  Leslie Henderson, Coral Reef Initiative Coordinator, Pedro Nieves, Program Coordinator | End User | Yes |
| University of the Virgin Islands | Dr. Marilyn Brandt, Research Associate Professor  Dr. Tyler Smith, Research Associate Professor | Collaborator | No |
| College of Charleston | Dr. Adem Ali, Assistant Professor | Collaborator | No |
| Kent State University | Dr. Joseph D. Ortiz, Professor | Collaborator | No |

**Community Concerns:**

* The economy of the U.S. Virgin islands is supported heavily by tourism, compromising about 30% of GDP and 27% of the USVI workforce. This industry is dependent on the condition of the natural environment which draws visitors and business.
* These natural environments that are critical to the territories economic success are susceptible to human-induced change. Concentrated and intense land-use by humans can cause sediment, nutrients and metals to flow from land into the ocean and subsequently harm the reef-building coral species that are the foundation of coral reef biodiversity.
* Climate change impacts such as increased storm intensity, ocean acidification and ocean warming impart additional stress on the delicate corals.

**Current Decision-Making Practices & Policies**:

The Department of Planning and Coastal Zone Management (CZM) uses multiple tools in the permit granting process. The department considers proximity to river or ocean, as well as soil type, slope and other nearby development. The CZM relies on remotely-sensed data generated from partnerships with nonprofits or researchers. The division created a Local Action Strategy (LAS) initiative in 2005 that was designed to identify and implement priority actions focusing on the conservation of coral reefs with four committees assigned to recreational use, land based pollutants, fishing, and lack of awareness. The LAS was developed in conjunction under the USVI’s Management Priorities plan as an ongoing effort to equip place-based, local coral reef jurisdictions with strategic goals and objectives. Both documents operate as foundational guidelines for long term conservancy where actioned goals on land work to protect the coasts’ biological value.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Land-use Maps | Land cover classification performed using Landsat 5 TM and Landsat 8 TM | This map will be used for identification of changes in land-use and land cover, and intensity of human impacts on both terrestrial and nearshore marine habitats. This can be used for decision-making processes pertaining to the evaluation of development permits at or near coastal areas. | N/A |
| Land-use Classification Tool | Landsat 5 TM and Landsat 8 OLI | This Google Earth Engine Code will be used by our partners to create additional land classifications. | III |
| Analysis of Land-use Change | Change detection analyzed using the Earth Trends module in TerrSet with Earth observations from Landsat. | Land-use change analysis will contribute to understanding of areas where the largest and most rapid rates of change have occurred. This can be used for decision-making processes pertaining to the evaluation of development permits at or near coastal areas. | N/A |
| Coastal Zone Risk Map | Analysis of EO-1, MODIS, Landsat, and Sentinel-2 will model coastal zones at high risk of impact due to land-use change on the islands | This will facilitate the identification of nearshore habitats with high risk. This complements current NASA-funded efforts dedicated to study the present condition of coastal and marine ecosystems in the USVI. | N/A |

**Project Benefit to End User**:

Our final product will provide CZM with resources for considering future developments in light of long-term land trends. The condition of the island’s coastal resources such as beaches, coral reefs, seagrass beds and mangroves is critical to sustain the territory’s tourism and overall economic success. Impacts to these resources are currently considered when making permitting decisions, but they are completed on a case-by-case basis without officially taking long-term effects and changes into account. Current zoning laws control what types of infrastructure can be developed on each land parcel, but comprehensive information to define overall development limitations and thresholds is lacking. Quantifications of current and historic land-use changes and identification of at-risk habitats produced from our project will facilitate permitting decisions made by the Department of Planning and Natural Resources, Coastal Zone Management so as not to disrupt the ecology that the island depends on economically.

**Project Details**

**Applied Sciences National Application Addressed:** Ecological Forecasting

**Study Area:** U.S. Virgin Islands (VI)

**Study Period:** January 1985 – June 2017; Forecasting to 2025

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| Landsat 5 TM | Land cover | These data are necessary to create yearly composite images that are processed to create land-use change maps. |
| Landsat 8 OLI | Land cover | These data are necessary to create yearly composite images that are processed to create land-use change maps. |
| Sentinel-2 MSI | Land cover | These data are necessary for creating a present day high resolution land-use map of our study area. |

**Ancillary Datasets Utilized:**

* US Census Bureau Population Data – population density
* NOAA Coastal Services Center Coastal Change Analysis Program (C-CAP) – land cover

**Software Utilized:**

* Google Earth Engine API - image processing and land classification of Landsat imagery
* Esri ArcGIS – map creation
* TerrSet – land-use change maps and time series analysis

**Project Handoff Package**

**Transition Plan:**

The summer 2017 DEVELOP team will formally present the finalized deliverables to the USVI Department of Planning and Natural Resources Coastal Zone Management by video conference at the end of the summer term. The final land-use maps, land-use change analyses, and coastal zone risk maps for the northern islands, St. John and St. Thomas will be handed off virtually.

*Software Release Plan:* The USVI end users at CZM have been notified that they will receive the GEE repository software following the DEVELOP Summer 2017 term. Data inputs required to run GEE scripts will be virtually shared to support code use. Should any concerns or questions arise, the DEVELOP team lead will remain in contact with USVI end users throughout the duration of the release.

*Project Continuation Plan:* The summer 2017 DEVELOP team will provide the summer 2018 team with land cover analysis products for St. John and St. Thomas, which can be expanded to include St. Croix. This will include the land cover maps from 1985 - 2016, coastal zone risk maps, and GEE repository that was used to produce land classifications. These items will supplement the summer 2018 team’s watershed hydrological analysis.

**Team POC:** Rebecca Lehman, rlehman54@gmail.com

**Software Release POC**: Rebecca Lehman, rlehman54@gmail.com

**Partner POC**: Jean-Pierre Oriol, jp.oriol@dpnr.vi.gov

**Handoff Package:**

* Land-use maps
* Land-use change maps
* Coastal zone risk map